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Published by
NATIONAL LUBRICATING GREASE INSTITUTE

VOLUME VIII • NUMBER 9 DECEMBER, 1944

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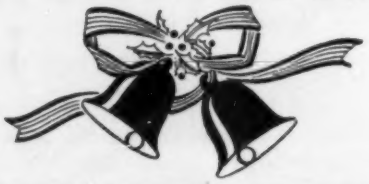


The Effect of Mineral Oil Pour Point on the Flow Characteristics of Lubricating Greases

C. W. Georgi and John F. O'Connell
Enterprise Oil Co., Quaker State Oil Ref. Corp.
Presented at 12th Annual Meeting N L G I

Many lubricating grease specifications contain a maximum limit on the pour point of the mineral oil constituent. A majority of such specifications cover automotive and industrial greases which are intended for use at normal atmospheric temperatures which rarely go much lower than about zero degrees F. The work reported herein deals with greases of this general type and not with the highly specialized extreme low temperature greases which are intended for service at temperatures far below zero.

There appears to be two schools of thought concerning the value or function of low pour point mineral oils in greases. The one school believes that mineral oil pour point is directly related to the mobility and flow characteristics of the finished grease at low temperatures and that low pour oils are accordingly necessary to insure good low temperature grease properties. The second school of thought proposes that since lubricating greases are specifically made to be non-fluid at temperatures below their dropping points, the pour point of the mineral oil is of no consequence and that the soap base constituent of greases nullifies any possible influence of mineral oil pour point.

Although these two schools are diametrically opposed, there seems to be little or no published data to substantiate either line of reasoning and frequent controversies arise. The chief objection to the use of low pour oils for grease manufacture relates to difficulties which sometimes arise in securing supplies of such oils having other desirable or essential characteristics for grease making, and many instances are on record where grease manufacturers have had to add pour point depressants to oil stocks in order to meet grease specification requirements on oil pour point.

In considering the mobility characteristics of greases it can be stated that as soon as a grease is removed from its original shipping container it is required to function essentially as a plastic or viscous fluid. This condition applies throughout the temperature range of use. The filling of grease guns or dispensing equipment, the movement of the grease through gun hoses or piping and into the parts requiring lubrication all involve grease flow. The effective or apparent viscosity of a grease thus governs its ease of handling and dispensing as well as the starting and running torques of lubricated mechanisms. Under such conditions, viscosity is a fundamental property of greases just as it is of lubricating oils. The essential differences between viscosity properties of greases and oils are, first, that a positive force or pressure is required to cause grease flow and, secondly, that the vis-

cosity of greases varies with the rate of shear or flow velocity.

As laboratory workers well know, the accurate measurement of oil viscosity involving only one variable, temperature, is not easy; so that viscosity measurement of greases involving three variables, temperature, pressure and rate of shear, becomes quite complex. It is probably for this reason that so little work has been done in evaluating the viscosity characteristics of greases, in spite of the fact this property is one of the basic fundamentals of grease lubrication. Fortunately, developments of the past few years have pointed the way toward eliminating this "blind spot" in lubricating grease technology.

The Pressure-Viscosimeter originally developed by the Standard Oil Development Company and described at the 1942 meeting of the National Lubricating Grease Institute (*Institute Spokesman,* November, December 1942 and January, February, 1943) was the first relatively simple grease viscosimeter suited for general laboratory use. The standardized design of this S.O.D. Pressure-Viscosimeter as made by the Precision Scientific Company is now available in about 25 to 30 laboratories and cooperative work is developing rapidly. This investigation concerning the effect of mineral oil pour point on the flow or viscosity characteristics of greases serves to illustrate the possible applications and usefulness of grease viscosity information.

Photo 1 shows the S.O.D. Pressure Viscosimeter, as made by the Precision Scientific Company, with the addition of a constant temperature cabinet surrounding the test cylinder. Photo 2 shows the unit with the constant temperature box opened. The air circulating fan, heaters and cooling coil are located behind the metal shield which serves as a "chimney" to provide uniform air circulation and temperature within the cabinet. Test temperatures of 77°, 100° or 130°F. plus or minus ½° can be maintained in this unit.

TABLE A

SODA BASE GREASES

Sample No.	*Worked Penetration*	*% Soap*	*Water*	*Dropping Point*	*Mineral Oil Vis. at 100°*	*Mineral Oil Vis. at 210°*	*Mineral Oil Vis. Index*	*Pour Point*
1	280	12.	Trace	340°	874	76.6	80	70°
2	285	12.	Trace	340°	874	76.6	80	15°
4A	270	12.	Trace	340°	1070	70.2	21	−5°
S	220	18.	Trace	390°	874	76.6	80	70°
G	280	11.	Trace	400°	1230	90	78	65°

Photo 3 shows a modified Pressure-Viscosimeter installed in an Aminco Constant Temperature cabinet which can be maintained at any desired temperature between plus 220° and minus 90°F. within plus or minus ½°.

FLOW CHARACTERISTICS OF SODA BASE GREASES

Table A itemizes the general properties of the Soda base greases used in the test work. Grease 1 was a typical short fibre No. 2 consistency Soda grease of the type commonly used for wheel bearing lubrication. A waxy steam refined stock was used as the principle mineral oil constituent and the oil base had a plus 70°F. pour point. Grease 2 was the same as Grease 1 except that 1% of a pour point depressant was added to the mineral oil stock to provide a plus 15° pour point.

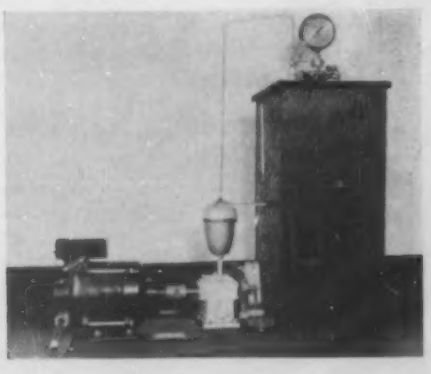
Grease 4A was made to be as nearly identical to Grease 1 as possible except that a low viscosity index, low pour point mineral oil was used. Grease S was prepared in the same way and from the same soap and oil bases as Grease 1, but was of No. 3 consistency. Grease G was made with a waxy, high pour mineral oil, very similar to that in Grease 1, but was processed to yield a long fibre grease. The first four greases listed in Table A were of the type generally described as soft, short fibre products, and the essential difference of Grease G was its hard or leathery, long fibre type of structure.

Figure I shows typical viscosity-shear curves as derived with the Pressure-Viscosimeter. It will be noted that the viscosity-shear characteristics of Greases 1 and 2 are practically identical, so that their viscosity or flow properties were not effected either at 77°F. or at 32°F. by the difference in mineral oil pour point, which was the only essential difference between these two greases. It is likewise noteworthy that Grease 4A, in spite of its quite different mineral oil constituent, displays flow characteristics very similar to Greases 1 and 2.

Figure I also illustrates a characteristic of all greases in that their apparent viscosities decrease rapidly with increasing rate of shear, or flow velocity. Thus, the three greases at 32°F. and at a rate of shear of 10 reciprocal seconds had an apparent viscosity of about 350,000 centipoises, but at a shear rate of 1,000 reciprocal seconds the apparent viscosity had dropped to only about 1/10 as much or 35,000 centipoises.

Grease flow through dispensing equip-

(Continued on Page 4)



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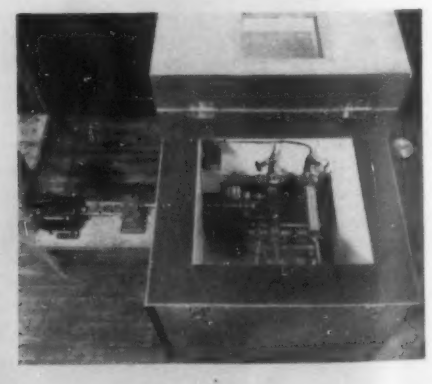

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Published monthly by

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*Post-War Small Cars**

Predictions of a low-priced, small automobile as a post-war product of the Ford Motor Co. arouses the interest of oil marketers as to the probable effect of such a vehicle on demand for crankcase and gear oils, and lubrication services.

A prediction based on a prediction gets a bit involved, but a low-priced car to supply the price-minded portion of the public with essential transportation is likely to insure a continuation of the mass market for lubricating oils, lubricants, fuels, and accessories in the post-war period.

The words "a price-minded portion of the public" have been selected carefully. Vehicle owners of this group have been the best customers for the oil industry's automotive products. The industry's principal market before the war was a mass market, not a class or luxury market, and without this mass market the industry would never have achieved such a tremendous demand for fuels and lubricants.

No Miniature Model

Rumors on Ford's post-war cars have been bolstered by published announcements recently attributed to Henry Ford II that his family has been thinking about such an auto. The announcement related that a low-priced car might be added to the line if the public demanded it, and that such a car would be a standard sized vehicle stripped of fancy trimmings, not a miniature car.

The crux of the statement is what will be the public's demand. Will income be so high that the vast majority of car owners can overlook original investment and operating costs? Or, will incomes be such that a large number of the public will have to consider price so there will be a demand for an inexpensive vehicle?

Prior to the war, the low-priced car dominated the field. It is true that Ford, Chevrolet, and Plymouth cars were getting away from "bare, essential transportation" models and were taking on more luxuries, yet of all automobiles registered in June, 1940, 62% were of these three makes. Total registration, given in Automotive Industries, was 27,700,000 passenger cars, and the "Big Three" accounted for 17,160,000 vehicles.

Ford provides a good analysis, as there were three distinct models produced: Model T until 1927, the Model A from 1928 to 1932, and the V-8 models from 1932 to 1942. The total number of Ford cars registered in June, 1940, of all makes and models was 6,814,386. Of this total, the number of Model T cars was 178,446, of Model A 1,908,530, and of the V-8 series 4,665,420. Unclassified as to year of manufacture were 61,990. In other words, of all Ford cars running around in June, 1940, about 30% were Models T or A, and those certainly were not luxury models.

A comparison of the lubrication requirements of the various Ford models is given in the accompanying table. The capacity of the crankcase jumped up 1 qt. when the change was made from the T to A, and the capacity of the differential was increased from 1½ lb. for the Model T to 2½ lb. for the V-8. Remember however, that the number of Model Ts produced far exceeded production of other models, and that more fuel and lubricants went through the Model T than through the older models.

Also, the Model T with its planetary transmission gear required no extra lubricant for the transmission. When Ford went to the standard gear system, a transmission capacity appeared on the lubrication charts. Model A transmissions required 1 lb. and the V-8 Models 2½ lb. of gear lubricant.

There are several other pre-war economic facts that come in handy for post-war product-demand thinking. The American Petroleum Industries Committee collected some information on who really pays the gasoline tax, and these studies clearly indicate the automobile is not a rich man's toy, but the poor man's essential transportation.

The Industries Committee studies indicated that the average American motorist had an income (pre-war) of $20 to $30 a week. U. S. Department of Commerce figures showed that a third of all car-owning families received less than $20 weekly; that 60% of car owning families had an income

(Continued on Page 6)

*Copyright Chek-Chart, Inc.

LUBRICATION REQUIREMENTS OF FORD MODELS

	Model T* (to 1927)	Model A** 1928-1931	V-8*** 1932-1942
Crankcase capacity, qt.	4	5	5
Differential capacity, lb.	1½	1½	2½
Transmission capacity, lb.		1	2½
Radiator capacity, qt.	12½	12	20
Fuel tank capacity, gal.	10	11	14
Under hood number of lubrication points	5	10	7
Type of lubricants	CG, MO	MO, CL, GL	GL, CL, MO
Chassis — Number of lubrication points	27	38	20
Type of lubricants	MO, WB, UJ, CG	CL, WB	CL, WB, UJ

GL—Gear Lubricant
CL—Chassis Lubricant
CG—Cup Grease
MO—Motor Oil
WB—Wheel Bearing Lubricant
UJ—Universal Joint Lubricant
*—Requirements for 1927 Model
**—Requirements for 1928 Model
***—Requirements for 1932 Model

(Continued from Page 2)

ment, gun hoses or pipe lines is at fairly low rates of shear in the range from 10 to a few thousand reciprocal seconds. When lubricated parts or bearings are started in motion, the shear rates are similarly low. The rate of shear existing in running bearings is in the order of several thousand to several million reciprocal seconds, and at these very high shear rates grease viscosities closely approach that of their mineral oil constituent. Grease viscosity data at the lower rates of shear accordingly are of most interest since these are directly related to the ease of handling and application and to the starting or break-away torques of grease lubricated bearings.

Since the oil industry has grown up with the Saybolt system of viscosity measurement, the Pressure-Viscosimeter data in fundamental units of centi-poises is somewhat like a foreign language and needs interpretation to be reduced to everyday terms. For purposes of approximation, multiplication of centi-poises by 5 will give the rough equivalent of Saybolt seconds viscosity. Thus at 32°F. and a shear rate of 10 reciprocal seconds, the greases in Figure 1 have viscosities of about 350,000 centi-poises or roughly 1¾ million Saybolt seconds.

Figure II shows Viscosity-temperature curves on the test greases at three different rates of shear. These curves were derived by making viscosity-shear determinations at several different temperatures and plotting the results on A.S.T.M. Viscosity-Temperature charts.

Greases 1, 2 and 4A display nearly identical apparent viscosities over the range from 10° to 210°F. Since Grease 1 contained a mineral oil of 70°F. Pour, Grease 2 of 15° Pour and Grease 4A of −5° Pour, it would seem, if pour points were a factor in grease viscosity properties, that there would be some more obvious indication, especially in the temperature range from 10 to 32°F. The conclusion to be derived thus seems to be that oil pour point had no appreciable effect on the viscosity-temperature characteristics of these soda base greases.

Figure III shows Viscosity-Temperature Curves for Greases 1 and 4A in relation to the viscosities of their respective mineral oil constituents. The mineral oil viscosity curves were derived by plotting the viscosities at 100° and 210°F. and drawing a straight line through these points as per the usual A.S.T.M. procedure. While these oil curves are most probably inaccurate in the extrapolated region below about 70°F., they do give an indication of the relation between the viscosities of the respective oils and finished greases. It will be noted that while there is considerable spread in viscosity between the two oils, the two greases are very similar and do not display nearly as much difference. This would indicate that the soda soap constituent of the two greases has a greater effect on their viscosity properties than does the mineral oil, particularly at the lower temperatures.

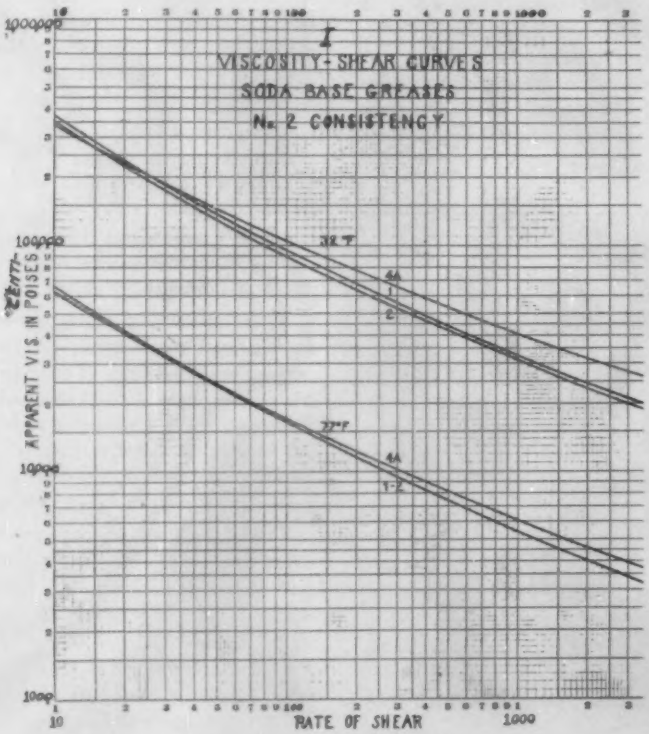
The curves in Figure III also illustrate the characteristically flatter viscosity-temperature curves of greases compared to mineral oils and that this property is most pronounced at higher temperatures.

Figure IV shows Viscosity-Temperature curves for Greases 1, G and S at 2 rates of shear. Greases 1 and S were prepared from the same soap and oil stocks, Grease 1 being of No. 2 Consistency and Grease S a No. 3 grade. The effect of the soap concentration on grease viscosity characteristics is indicated by comparison of the curves for Greases 1 and S wherein all properties were substantially the same except for soap content and consistency.

Grease G, of No. 2 consistency but having a hard, long fibre structure, shows a much flatter viscosity-temperature curve than any of the other test greases. At the lower temperatures Grease G has viscosities nearly the same or even lower than greases 1 and S, while at elevated temperatures its viscosities are higher than Greases 1 and S.

This condition seems to provide conclusive evidence that mineral oil pour point is of little consequence to the viscosity characteristics of soda base greases and that the type of soda soap structure is a much more important factor, more so even than the concentration of soap.

Figure I



Conclusions:

Based upon the experimental evidence derived with the Pressure-Viscosimeter, the following conclusions seem reasonable:

1—Pour point depressants in oil stocks used in soda base greases have no appreciable effect on the viscosity-temperature characteristics of the resulting greases.

2—Mineral oil pour point has no influence on the viscosity-temperature properties of soda base greases, and low oil pour points will not insure good low temperature mobility. Conversely, high oil pour points will not necessarily mean poor low temperature grease properties.

3—The factors having a major influence on the viscosity-temperature properties of soda base greases seem to be as follows and are listed in the apparent order of importance.

(a) Type of soda soap structure.

(b) Concentration of soda soap.

(c) Mineral oil viscosity.

The conclusions itemized above apply only to soda base greases and not to greases made with other soaps. Similar work is in progress with other types of greases and will be reported at a later date.

APPENDIX:

Numerous comments have been made recently, which indicate a rather wide spread belief that the Pressure-Viscosimeter will ultimately replace the A.S.T.M. Grease Penetrometer, and there seems to be some confusion as to the relative usefulness of pressure-viscosity data and consistency tests in grease evaluation.

The following definitions indicate the difference between the properties of consistency and viscosity or mobility.

Consistency—Measure of the relative resistance of a plastic material to permanent change of shape.

Viscosity—Measure of the relative resistance of a fluid to continuous flow.

Mobility—Measure of the relative resistance of a plastic material to continuous deformation or flow under a positive pressure.

Consistency is accordingly a property of greases under static conditions, whereas viscosity or mobility is a property under dynamic conditions. Consistency and viscosity are thus two entirely different properties of greases and both are useful and necessary. Consistency measurement is still needed to indicate the degree of hardness or softness desired for any given grease and is most useful as a quick and simple identification and control test. Viscosity measurement, on the other hand, provides information on the application and service properties of greases, particularly as related to ease of handling and dispensing and to starting and running torques of grease lubricated mechanisms.

Figure II

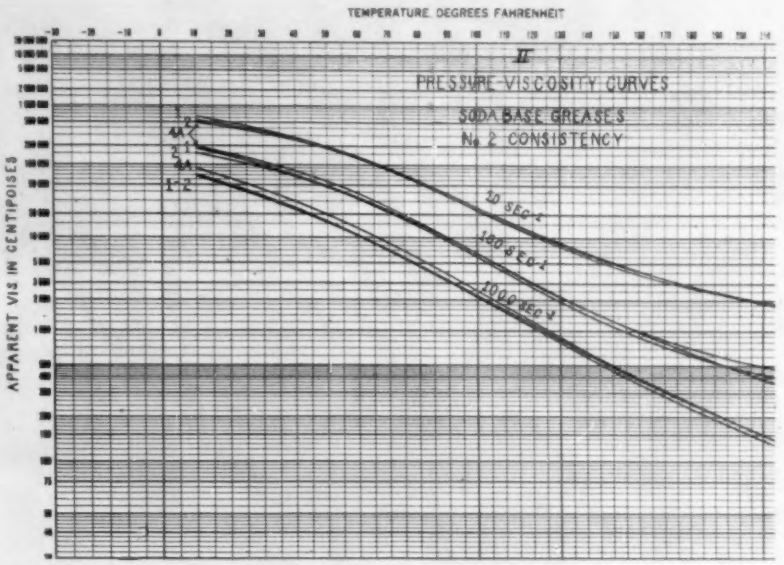


Figure III

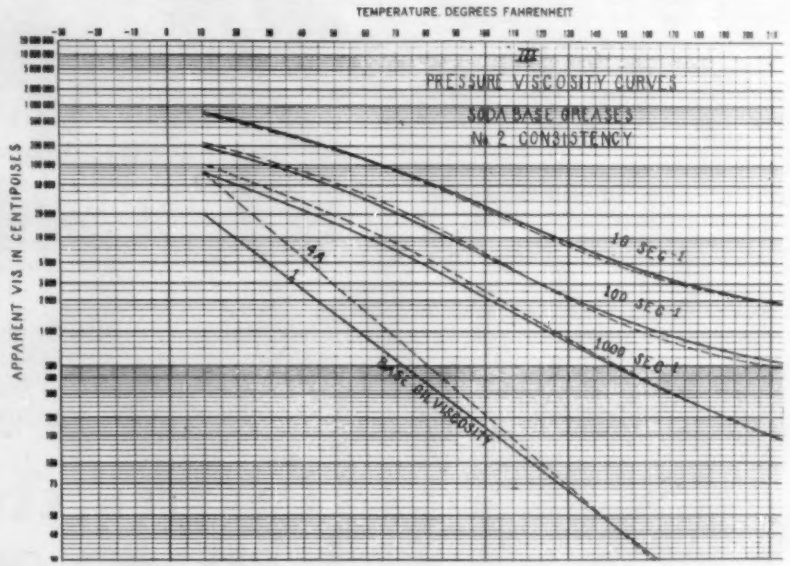
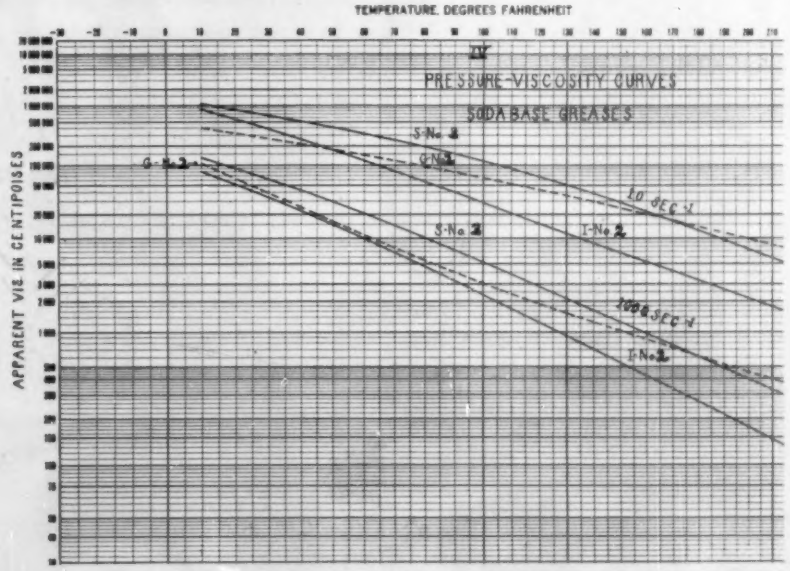


Figure IV



Buy Bonds

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POST-WAR SMALL CARS

(Continued from Page 3)

less than $30 weekly. Only 12.4% of car owners earned over $60 a week.

A man earning $20, $30 or some such figure each week is not exactly in the bread line, but on that income one does not usually purchase high priced automobiles.

The Industries Committee studies also revealed the fact that 60% of car owners never purchased a new vehicle. This 60% has been content with used cars, ranging all the way from rather good models, which have just been traded-in by the original owners, down to the delapidated $25 (pre-war value) jalopies.

Reports of high wages paid during war time might naturally lead to the false conclusion that everyone enjoys prosperity, and never again will there be incomes as low as $20 a week. It is a happy thought, but right now economic conditions are upset, and things may be different after the war.

"Rosie the Riveter," her husband, and the children, may represent the upper crust of financial society. Ordinarily Rosie's family might be in that group of car owners who never bought a new auto, but right now it might be able to lay cash on the line for a big, new automobile, if such a thing were available.

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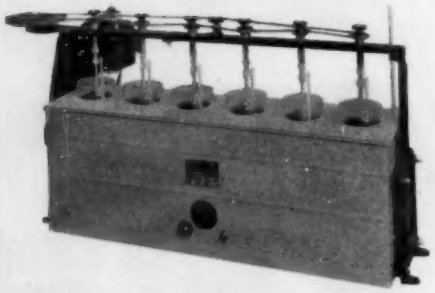

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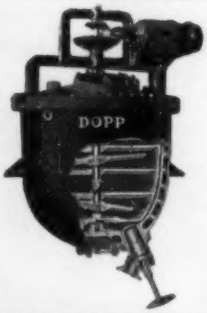

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THE CHEK-CHART CORP.
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